Shaw The Shaw Group Inc.

Pilot Scale *In Situ* Chemical Oxidation Without Aquifer Acidification

Presentation Overview

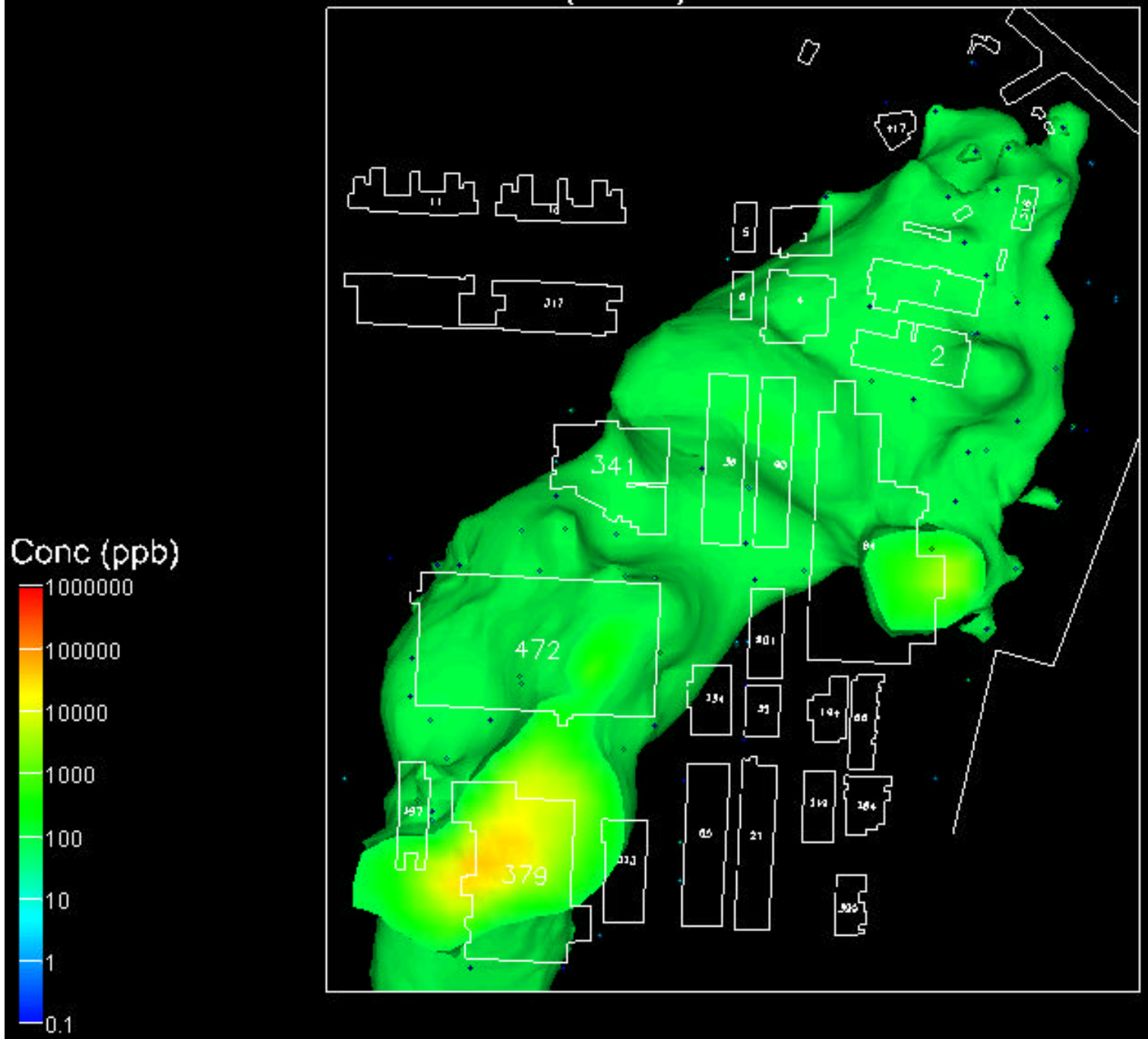
- Project background and site description
- Overview of pilot study methods and implementation
- Results and conclusions
  - TCE changes in groundwater, soil and soil vapor
  - Changes in geochemical environment
  - Affect on natural attenuation parameters
  - Recommendation for effective full-scale implementation

Project Background

OU20 is Dissolved Phase TCE Plume

- Primarily TCE; also contains degradation products and 1,1,1-TCA
- TCE concentrations up to 100,000 mg/L - PAL is 92 mg/L
- Extent: ½ mi horizontally and up to 80 feet vertically
- Multiple techniques used to delineate, including membrane interface probe and diffusion sampling

Trichloroethene (TCE) - Concentration at 92 ppb



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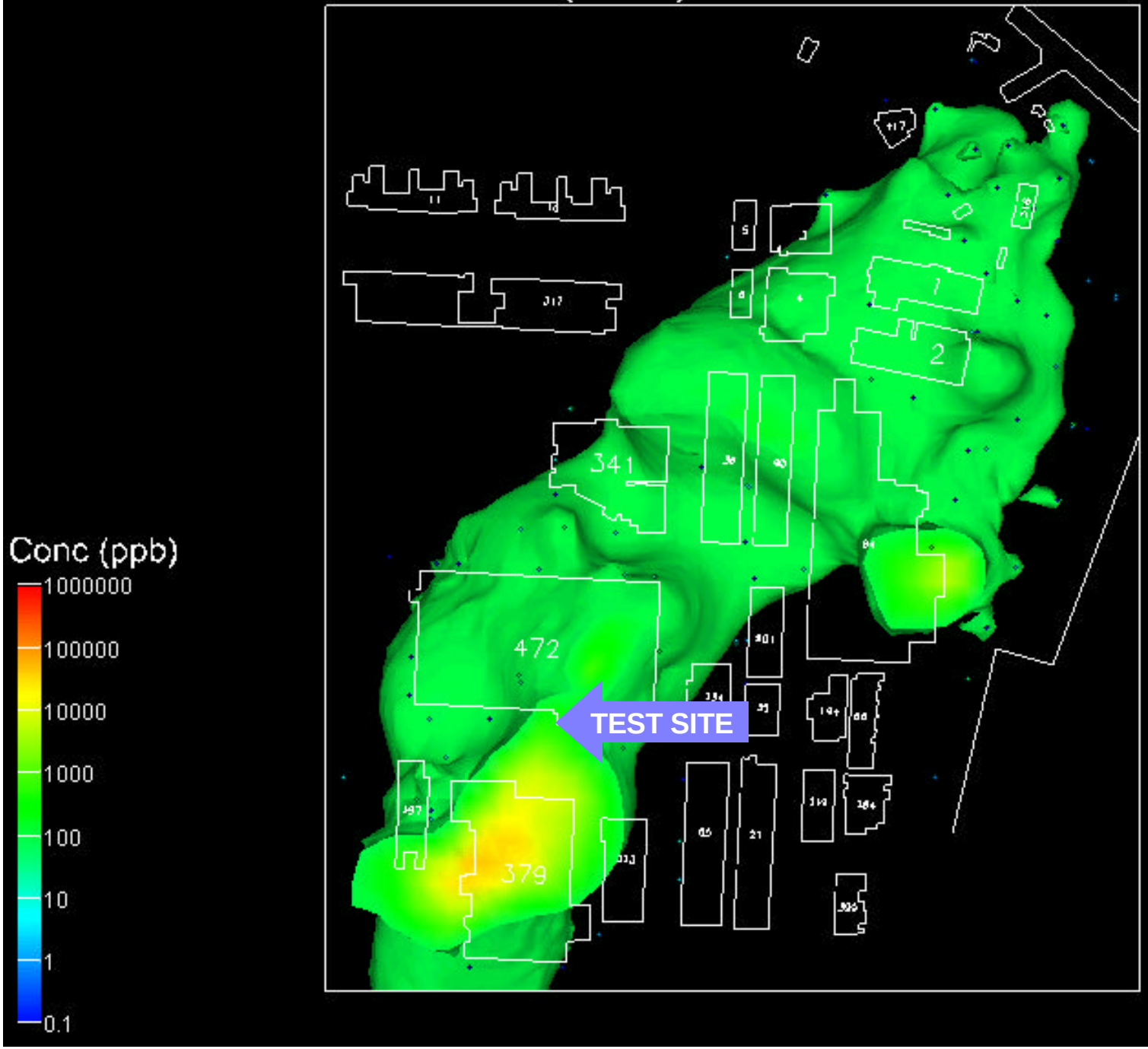


Pilot Test Objectives

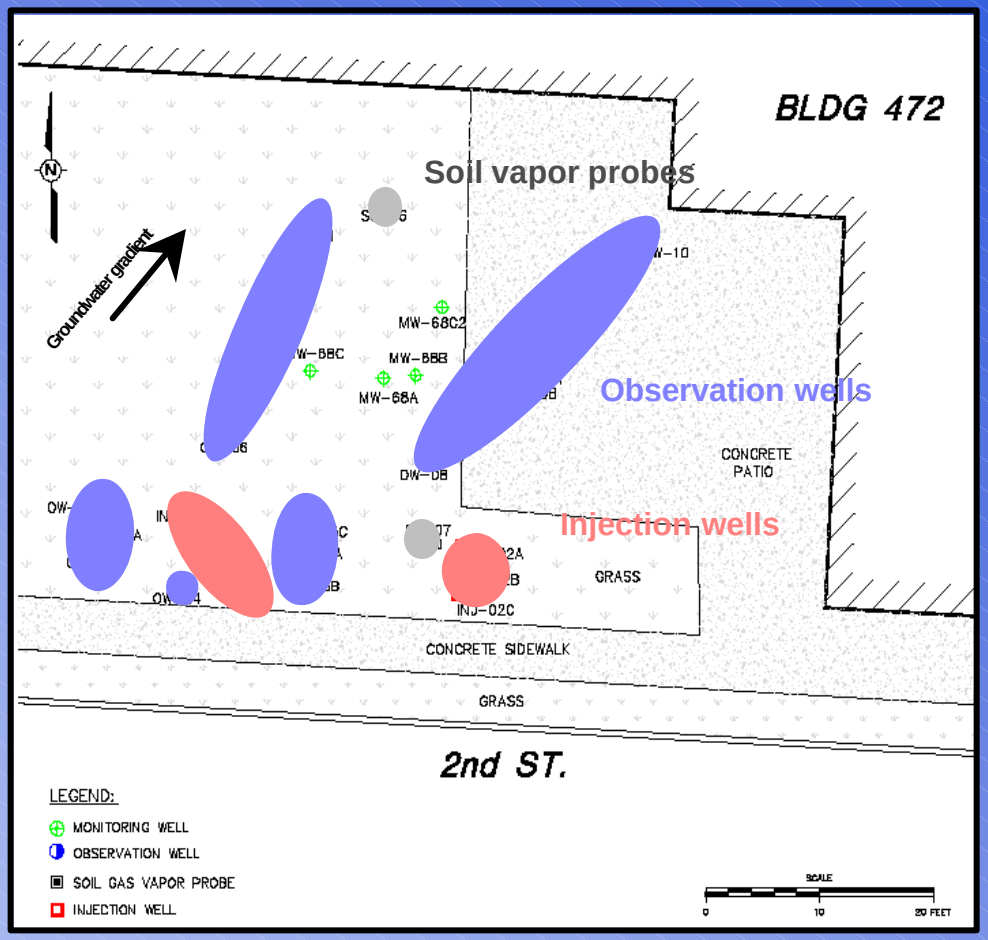
- **Busy area: Use non-acidified, less aggressive, *in situ* Fenton reagents to determine if process can reduce TCE in groundwater to PAL of 92 mg/L**
- **Evaluate cost effectiveness of potential full-scale remedial application and provide data needed for full-scale design**
- **Determine if process negatively affects geochemical equilibrium**

Implementation

- Modified Fenton-type chemistry with H_2O_2 and Fe^{2+}
  - Bench and field tests conducted by ISOTEC
  - Bench test successfully reduced TCE in lab setting
- Field Test
  - Criticism is dilution: Tracer test conducted prior to start of chemical injections
  - Three chemical injection events
  - Seven sampling events, including baseline, interim and post test

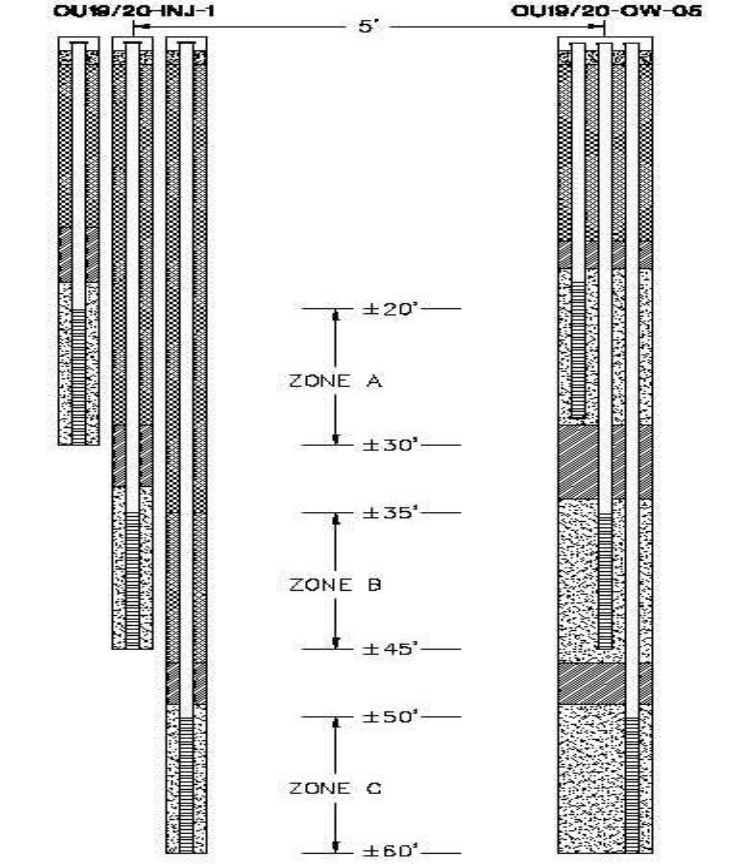
Test Area Layout

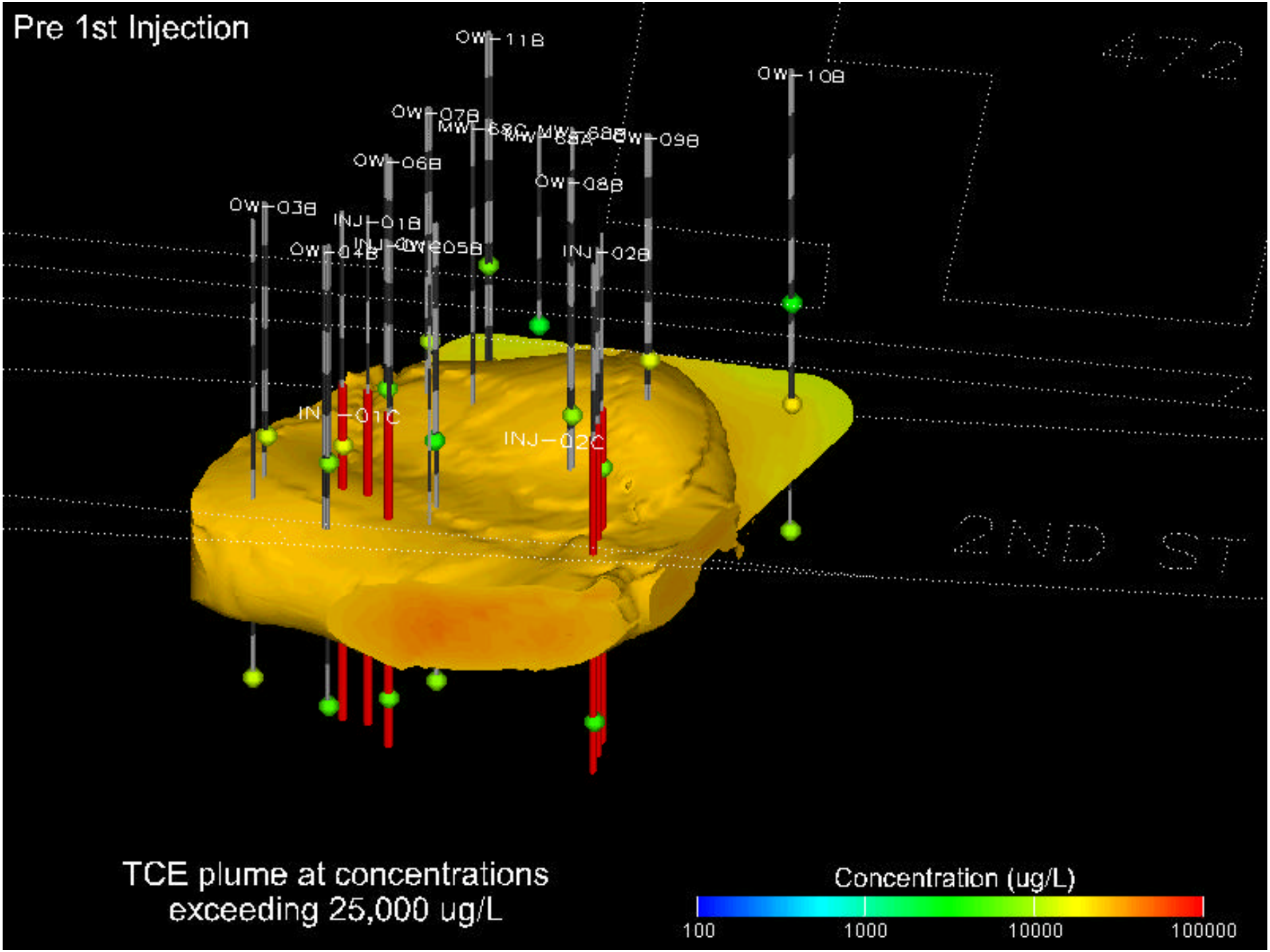
- Two injection well clusters
- Ten observation well nests placed at ~5-ft radial distances to 30 feet down gradient
- Two vapor probe nests
  - Discreet screens placed 2, 10 and 20 feet below grade
  - H&S monitoring

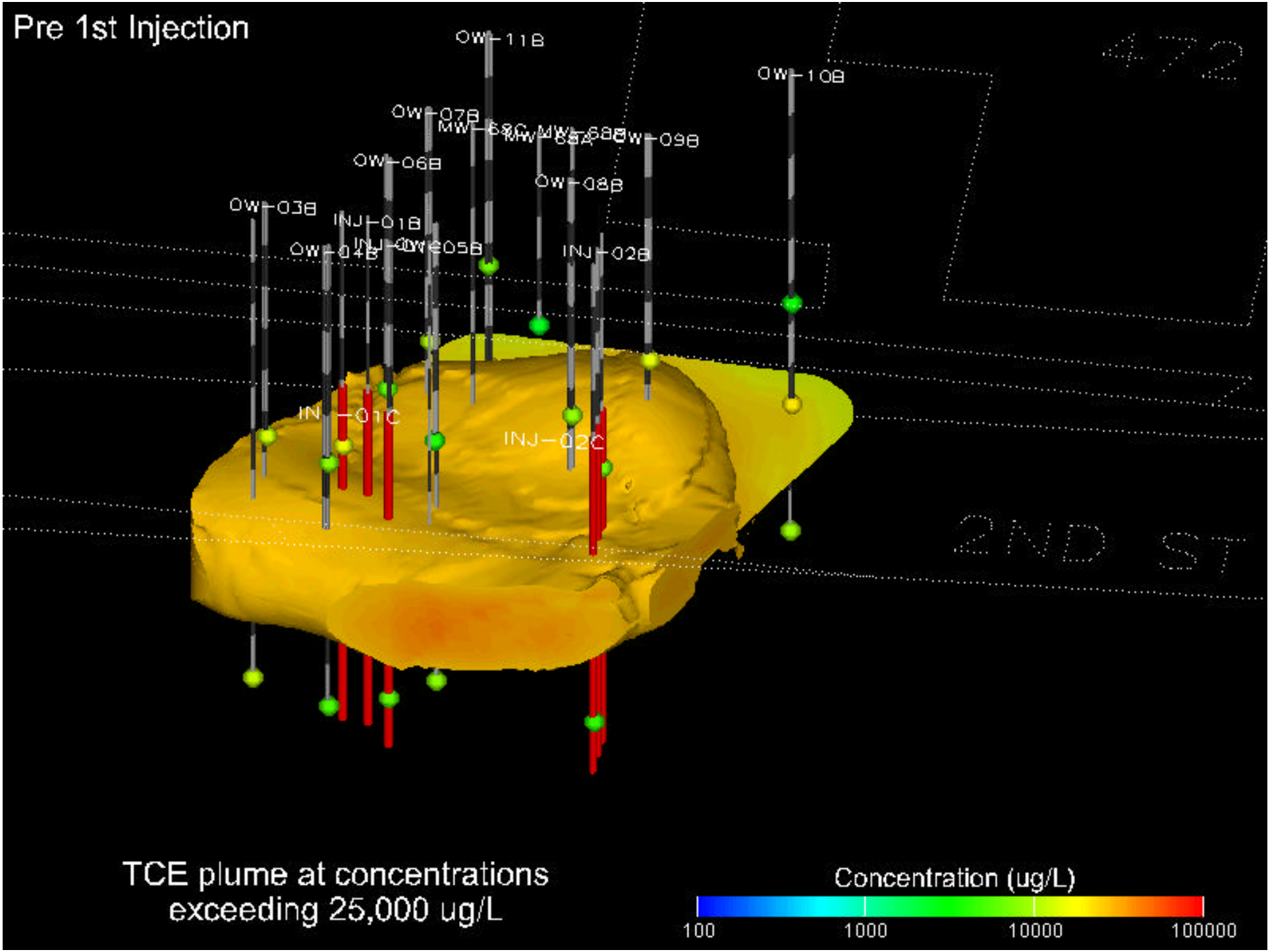


Injection and Monitoring Zones

- Zones A, B and C pilot test targets
  - A & C Zone TCE ~ 10,000 mg/L
  - B Zone TCE ~ 50,000 to 100,000 mg/L
- Zone D within clay in test area, therefore not included in pilot test
- Clustered injection wells
  - Individual wells Zones A, B, C
- Nested observation wells
  - Isolated screens Zones A, B, C




Pre 1st Injection
OW-11B
OW-10B
OW-07B
OW-09B
OW-06B
OW-08B
OW-03B
INJ-01B
OW-04B
OW-05B
INJ-02B
INJ-01C
INJ-02C
2ND ST
TCE plume at concentrations
exceeding 25,000 ug/L
Concentration (ug/L)
100
1000
10000
100000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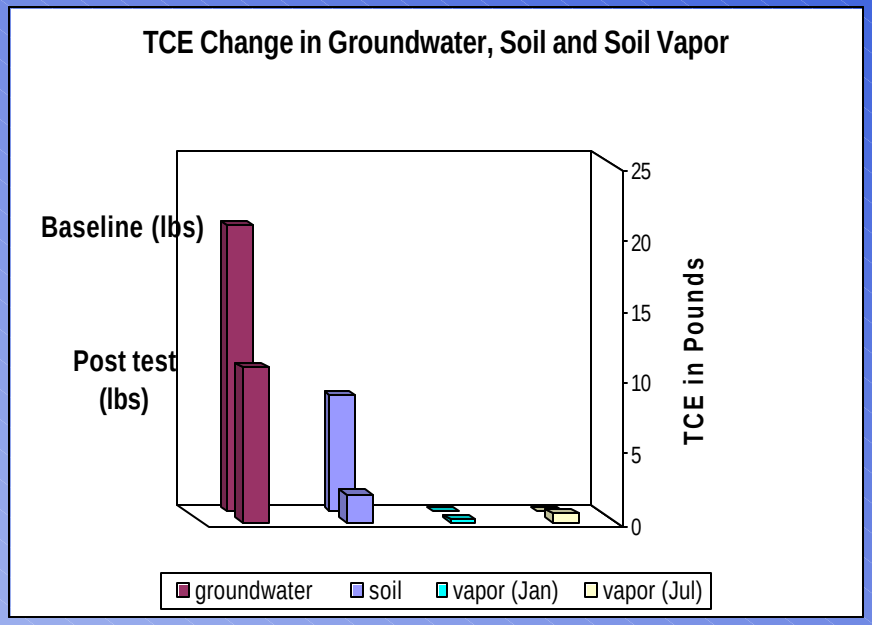
TCE Result Summary

- **Groundwater**
  - **26 of 35 locations showed reduced TCE**
  - **9 of 35 locations showed increased TCE**
  - **Average change was reduction of 11,000 mg/L (46%)**
  - **PAL was *not* achieved**
- **Soil**
  - **Samples collected from Zone B near injection wells**
  - **2 of 2 locations showed reduced TCE**
  - **86% and 62% reduction in concentration**

TCE Results Summary (con't)

- **Soil Vapor**
  - Results suggest some mass movement into vapor phase
  - Approximately 2% to 4 % of total mass (insignificant)
  - Monitoring indicated no H&S concerns
  - But, SVE becomes important component in full-scale design



Geochemical Changes

- $Cr^{3+} \rightarrow Cr^{6+}$ not observed
- Some unexpected results
  - pH down by 1 unit near injection wells
  - Temperature increased by up to 40 ºF near injection wells; no increase observed outside ~5-ft radius
  - Increased ammonia concentrations
  - Increased alkalinity and total organic carbon
- But, NO “fatal flaws” observed

Affect on Natural Attenuation Process

- Prior to test, adequate evidence that natural attenuation occurring at site
  - Daughter products present
  - Indicators suggest reductive dechlorination occurring
- After test, observed TOC increase suggests significant redox buffer capacity still exists at the site
  - Site not “over oxidized”
  - Return to reducing conditions could be expected
- Natural attenuation potential follow-on for continued site remediation

Conclusions

- TCE was destroyed within the test area
- Dilution and dispersion cannot account for all observed reduction in TCE concentrations
- Geochemical "fatal flaw" was *not* observed
- PAL for TCE was *not* achieved, BUT
  - Determined cost effective as source reduction
    - Most "bang for buck" on initial application
  - Natural attenuation or enhanced *in situ* bioremediation feasible as follow-on

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